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Structural and distributional evaluation of forest ecosystems in Turkey

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Abstract: *Turkey has very rich ecosystems and habitats in which various types of vegetation communities and fauna are found. These properties of Turkey depend on its geographical position, different climatic region, mountainous topographical conditions and climatic changes occurred during the Pleistocene. Several field works have been conducted during the period of 1975-2008. The field observations and analyses of data reveal that Turkey's forests can be divided into six main forest ecosystems (Black sea region, Marmara transitional region, Mediterranean region, Mediterranean transitional region, Inner and Eastern anatolian region, Southern anatolian region) in terms of floristic composition, forest productivity and climatic properties.*

Key words: *Forest ecosystem, Turkey, Black Sea region, Miditerranean region*
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Introduction

Turkey possesses a rich variety of vegetation due to its geomorphologic features and vaieties of ecological conditions. Turkey is located at the intersection of phytogeographic regions of Mediterranean, Euro-Siberian and Irano-Turanian (Atalay, 1994, 2002; Guner *et al*., 2000; Yilmaz *et al*., 2003). Their distinctive vegetation reflects differences in climate, geology, topography, soils and floristic diversity and human impact. Ninety percent of the forests in Turkey are 'natural' in origin and contain over 450 species of trees and shrubs (Kayacik and Yaltirik, 1971; Akman, 1995; Colak and Rotherham, 2006). Turkey has 21.2 million ha of forest, covering 27% of the land surface of the country. Most of these forests occur in the mountains. About, 53.3% of the forests in Turkey are composed of broadleaf species, 42%of coniferous species and 4.5% mixed coniferous and broadleaf forests (Louis, 1939; Mayer and Aksoy, 1986). Furthermore, the mountainous landscapes of Turkey, with their remarkable bioclimatic, geomorphological and pedological diversity, support a great many different high mountain vegetation types (Ozturk *et al*., 1991; Atalay, 2002; Parolly, 2004).

Turkey, which takes place on Alpine-Himalayan orogenic belt has high and mountainous topography. There are two main orogenic belts: Northern Anatolian Mountains in the north and Taurus Mountains in the south. Isolated volcanic cones higher than 3000 m in altitude are found in the Inner and Eastern part of Anatolia. Horst and graben systems are common in the western and eastern Anatolia. Orogenic belts have been deeply dissected by the rivers flowing into seas. These various topographic forms are responsible for the formation of different habitats. Three main climatic types prevail in Turkey. The northern part of the Anatolia is under the effect of humid and cold humid climates. Mediterranean climate prevails in the western and southern part of the Turkey. Continental climate prevails in the inner and eastern part of Turkey (Atalay *et al*., 2008; Ozturk *et al*., 2008; Atalay and Efe, 2008). Turkey has various soil types due to the diffrent climatic regimes, landforms, parent material. Geomorphological features and climatic variations produce major contrasts in soil types between the interior and the periphery. Spodosols occur mainly in the mountainous areas in the northern Turkey which is favourable to the growth of forest formation including both decidious and conferous forests. Alfisols occur on the karstic land on the Mediterranean cost. Aridisols are characteristic of the driest parts of the country, mainly in the semiarid zones of southeast Anatolia and central Anatolia. Broad-leaved deciduous forests and humid-cold coniferous forests occur on the asidic soils on the northern Anatolia (Atalay, 1994). This paper reviews the structural and distributional features and ecology of the forests in Turkey. This study is based on the published literature and extensive field investigations to determine the existing ecological properties of the forests.

Materials and Methods

The study was carried out all over Turkey and based on mostly field investigations. Field studies were conducted several times in the years between 1975 and 2008. The forest management maps also have also been used to determine the distribution of species.

Published books and scientific articles on forest vegetation in Turkey were reviewed. Meteorological data obtained from Turkish State Meteorological Service were interpreted in order to determine

the effect of climate on the distribution of forests in Turkey. Linear vegetation transects lines were established in several areas along the Black Sea and Mediterranean Sea cost in order to find out the impact of aspect. Various studies have been carried out in Turkey on the forests. These studies are mostly on forest management, and botanics. A few ecological studies in different regions of Turkey were conducted (Atalay, 2002; Yaltirik, 1973; Mayer and Aksoy, 1986).

Results and Discussion

The vegetation of Turkey is classified according to ecoregions and biomes. Main climatic conditions and the dominanttree species were taken into consideration in the classification of the forest formations. On the other hand, each phytogeographical region fits the main zonobiomes or main climatic regions. Climate geomorphology and aspect influence the distribution of the vegetation. The mountainous regions form a separate ecological environment and altitudinal belts are common along the mountains. The forest of Turkey can be divided into six main ecoregions (Atalay, 2002; Atalay and Efe, 2008).

(I) Forests of Black Sea region: Black Sea ecoregion extends from Istiranca Mountains in the west to the Artvin, Georgian border in the east. Black Sea region that characterized by mild-humid and cold-humid climates prevail in the north of Turkey. The mean annual temperature varies between 14 to 10°C along the coastal belt up to 1000 m. The average temperature is about 10-6°C between 1000 and 2000 m. The eastern part of the region is highly humid with an average of 1,500-2,500 mm annual precipitation. The western part of the region is less humid and receives between 1,000 and 1,500 mm of average annual precipitation. All seasons are rainy but the amount of the rainfall of the seasons varies. The mean annual precipitation is over 1000 mm and humid and perhumid climatic conditions prevail in the region. But, these semiarid subhumid conditions are dominant in the valleys such as Çoruh, Gökirmak, Kelkit and Devrez which are located backward section of the region. The most arid part of the region is the Yusufeli district and its vicinity in the Çoruh valley. During the summer period the northern slopes of the mountains are covered with fog. Foggy habitats lead to the decrease of the transpiration. Thus, most of the species are hydrophytic and hydrophyle character in these areas.

Humid broadleaf deciduous (*Fagus orientalis* Lipsky, *Castanea sativa* Mill, *Alnus glutinosa* (L) Gaertn. subsp. *barbata* (C.A. Mey.) Yalt., *Tilia spp.* and *Quercus spp.*) forests: Black sea region is very rich in terms of plant species and communities. It has more than 6000 plant species. Forests are composed of different species and floristic composition. Understory flora is associated with *Rhododendro*n species in general. Main forest communities along the coastal belt of Black Sea are as follows:

Eastern Black sea subregion: The high mountains exercise a predominant influence on the climate, and thus on the vegetation. Broadleaf deciduous forests constitute the main vegetation type. The main forest type of this region is *Fagus orientalis* Lipsky and it begins at the seashore and continues as high as 1700 m. The tree composition of these forests varies depending on altitude. *Quercus petrea* ssp. *iberica* (Steven ex Bieb.) Krassilin, *Castenea sativa* Mill., *Acer leatum, Acer cappadocicum* var. *stenocarpum* Yalt., *Zelkova carpinifolia* (Pall.) Dippel, T*ilia* spp. and *Pterocarya fraxinifolia* (Lam.) Spach. are other broadleaf species in the oriental beech forests especially on the altitudes between 500 and 1200 m. It has a rich broadleaf understory, including species such as *Rhododendron* spp., *Laurocerasus officinalis* Mill., *Ilex aquifolium* L., *Hedera helix* L. and *Buxus sempervirens* L. (Atalay, 1984; Atalay, 1992b).

On the other hand, oriental spruce, *Picea orientalis* (L.) Link. becomes dominant species at an elevation of 1200 to 1500 m. Besides pure oriental beech forests, the other mixed forests combination of beech and oriental spruce; *Fagus orientalis* Lipsy+ *Picea orientalis* (L.) Link. + *Alnus glutinosa* (L.) Gaertn. subsp. *barbata* (C.A.Mey.) Yalt.; *Fagus orientalis* Lipsy + *Castanea sativa* Mill; *Fagus orientalis* Lipsy, *Castanea sativa* Mill + ***Tilia*** *rubra* D.C. subsp *caucasica* (Rupr.); *Fagus orientalis* Lipsy + ***Abies*** *nordmanniana* (Link.) Spach.; and ***Abies*** *nordmanniana* (Link.) Spach.+ *Fagus orientalis* Lipsy+ *Picea orientalis* (L.) Link are found. They have a rich understory of ferns and vines (Atalay, 1994, 2002).

Middle Black sea region: The natural forest of the subregion is deteriorated and degraded considerably due to densely populated rural settlements. Productive *Fagus orientalis* Lipsky forests are common on the upper part of the Canik mountains in the vicinity of Akkus. Oriental beech forests occupy the southern part of Bafra district is composed of *Castanea sativa* Mill., *Alnus glutinosa* (L.) Gaertn. subsp. *barbata* (C.A.Mey.) Yalt., *Alnus glutinosa* ssp. *glutinosa* Mill., *Prunus* spp. and *Carpinus betulus* L. The understory of such forests covered by mainly thick vegetation composed of *Rhododendron* spp.

Western Black sea subregion: Coastal mountain ranges, deeply dissected river valleys such as Gökirmak, Devrez and backward mountains named Bolu-Abant-Köroglu Mountains determine the distribution of the vegetation cover. The forests in the Wastern Black Sea region support a higher diversity of woody species, with up to 25 different tree species per 1000 m^2 around Bolu, Zonguldak and Bartin.

Coastal mountains having productive *Fagus orientalis* Lipsky forests and their floristic compositions in the coastal belt are associated with *Pinus brutia* Ten., *Laurus nobilis L., Castanea sativa* Mill., *Tilia argentea* Desf., *Tilia tomentosa* Moench, and *Carpinus betulus L.* On the higher parts *Pinus sylvestris* L., *Abies bornmulleriana* Mattf. and mixed *Fagus orientalis* Lipsky forests occur. These are high forests with two or three structural layers, and a well-developed understory with abundant bushes. The most common species are *Taxus baccata* L., *Rhododendron flavum* Don., *Quercus cerris* L., *Quercus petraea* Lieble., *Prunus laurocerasus* L., and *Cornus mas* L.

Coastal belt of Marmara subregion: Broadleaf deciduous forests are common in Yildiz Mountains in Thrace and Catalca and Kocaeli Peninsulas, two sides of Bosporus (Istanbul Strait). *Fagus orientalis* Lipsky*, Carpinus betulus* L.*, Carpinus orientalis* Mill. and *Quercus hartwissiana* Steven., *Quercus cerris L., Quercus petraea* Lieble., are dominant forest elements in this region. The northern part of the Kocaeli peninsula is the main occurrence areas of oak, oriental beech and sweet chestnut forests. In Yildiz Mountains oriental beech forests begin at an elevation of 250-300 m in the coastal belt and cover the upper part of the mountain, and go on at an elevation of 500 m of the southern sector of the mountains (Donmez, 1968,1979; Atalay, 1987). Although forests on the north of Istanbul are composed of oak forests in general, *Fagus orientalis* Lipsky*, Castanea sativa* Mill. communities occur in small clusters (Yaltirik, 1973).

Humid-subhumid coniferous (*Picea orientalis* (L.) *Link*., *Abies nordmanniana* (Stev.) Spach subsp. *nordmanniana*, *Pinus nigra* Arnold. subsp. *pallasiana* and *Pinus sylvestris* L.*)* forests: Coniferous forests represent to a higher part of the mountains on which cold and humid climatic conditions prevail. The tree species and forest communities change depending on the fog formation level and sunny habitats of the mountains. Pure and mixed *Picea orientalis* (L.) Link., and *Pinus sylvestris* L. and *Abies nordmanniana* (Stev.) Spach subsp. *nordmanniana*,forests are common in the east; meanwhile in the middle and western part of the Black sea subregions *Pinus sylvestris* L., *Abies bornmulleriana* Mattf. and *Pinus nigra* Arnold. subsp. *pallasiana* occur on the slopes facing south of the Northern Anatolian Mountains.

Picea orientalis L. (Link.) forests occur only in higher elevations between 1500 and 2000 m in the places where upslope fog formation is common. As a matter of fact, the northern slopes of the Eastern Black sea mountains are covered with the heavy fogs during the summer season. Shrub layer of *Picea orientalis* (L.) Link. is associated with the *Rhododendron* species, in general (Atalay 1994). The sunny habitats of the northern Anatolian mountains are the main occurrence areas of *Pinus sylvestris* L. In fact, pure scots pine forests are common in the upper plateau surfaces of the Northern Anatolian Mountains and in the interior part of the mountainous areas. Cedar is found as a relict in small cluster inland section of the Black sea region in the vicinity of Niksar.

Abies bornmulleriana Mattf. forest is widespread on the slopes facing north in the middle part of the Black sea region. On the contrary, black pine forests, growing somewhat in the continental part, occur on the lowland part of the mountainous areas. These forests are replaced by *Pinus sylvestris* L. forests on the upper part of the mountains. The best sample of this can be observed in the Kastamonu Plateau, in the middle part of the Black sea subregion.

The higher parts of the mountains receiving the fog and the northern slopes of the Abant and Bolu mountains are the principal occurrence areas of the pure and mixed fir forest.

Dry oak (*Quercus sp.*), black pine (*Pinus nigra* Arnold. subsp. *pallasiana*), red pine (*Pinus brutia* Ten.) forests: The effects of drought increase towards the backward part of Black sea region. So that, dry forests begin on the bottom lands of the tectonic corridors and lower levels of the wide river valleys and their south facing slopes in backward section of the Black sea region (Fig.1). These forests are characterized by *Quercus* spp., *Pinus nigra* Arnold. subsp. *pallasiana* and *Pinus brutia Ten.,* and shrub formations most of which belong to the Mediterranean phytogeographic region (Atalay 1987, 1994).

Shrub (Pseudomaquis and Maquis) formation: Western Black sea region contains both Mediterranean shrubs and mild-humid Black sea region tree elements called pseudomaquis. Pseudomaquis elements are widespread as a narrow belt along the Black sea coast. This shrub formation has been developed as a result of the destruction of the broadleaf deciduous forests. In other words, destroyed forests are mostly replaced or covered with pseudomaquis. Maquis elements are also common in the bottom land of the valley and the tectonic depressions lying in the backward of the Black Sea Region.

(II) Marmara transitional egion: This region, surrounding the Marmara sea, is the transitional region between Black sea mild-cold humid climate in the north and Mediterranean climate in the south and west. For this reason it contains both Mediterranean and Black Sea region vegetation.

Marmara Transition region can be divided into three subregions.

Broadleaf deciduous forests: These forests that mainly composed of *Fagus orientalis* Lipsky*, Tilia tomentosa* Moench.*, and Castanea sativa* Mill. occur on the northern slopes of mountains in this region. *Fagus orientalis* Lipsky forests occur between approximately 800-1000 m elevation along the slopes of western part of Samanli Mountains, East of Marmara Sea and south of Izmit graben. Oriental beech forests begins from 200 m the in the eastern part of Samanli mountains reach up to 1000-1100 m in the northern part of the mountains. In this area oriental beech forests occur in mixed stands with *Carpinus betulus* L., *Tilia tomentosa* Moench.*, Pinus nigra* Arnold. subsp. *pallasiana* and *Pinus sylvestris* L.

Rhododendrons spp. which are only found as understory of oriental beech forests in the eastern part of Samanli Mountain indicate the effects of the Black Sea oceanic climatic conditions. Combination of *Abies bornmulleriana* Mattf. and *Fagus orientalis* Lipsky mixed forests occur on the southern slopes of the Uludag (Bursa) and Domanic mountains.

Humid airmasses come from north are intercepted by mountains and northern slopes of the mountains receive abundant rainfall. Coniferous forests are dominant at the upper elevations. *Abies bornmulleriana* Mattf. forests are common on the north facing slopes where fog is formed. *Pinus nigra* Arnold. subsp. *pallasiana* forests are widespread on the sunny habitat of mountains in the

south. For example; good stand black pine forests with oriental beech along the valley are widespread on the slopes facing north. Uludag, supports many Euro-Siberian elements such as *Fagus orientalis* Lipsky, *Abies bornmulleriana* Mattf., and *Pinus sylvestris* L. Open areas near tree line are often covered in a closed shrub layer.

***Pinus brutia* Ten. and *Quercus sp.* forests:** In the Marmara subregion, the forests are associated with *Pinus brutia* Ten. and oak forests *Quercus sp.* mainly found on the lowland and the south-facing slopes of the mountains. *Arbutus andrachne* L., *A. Unedo* L., *Spartium junceum* L., and *Laurus nobilis* L. are the main species of maquis vegetation on the southern coastal belt of the Sea of Marmara. *Quercus coccifera* L., *Calicotome villosa* Link., *Palirus spina-cristi* Mill., and *Erica arborea* L. are become dominant species in the areas where *Pinus brutia* Ten. has been removed.

(III) Mediterranean phytogeographical region: It covers surrounding areas of Marmara Sea in the NW part of Turkey. Black sea humid mild and Mediterranean climatic conditions prevail in the Marmara transitional region. Thus, this region contains both Mediterranean and Black sea vegetations.

The mean annual temperature ranges between 18 to 14°C from the south to the north. Mean January temperature changes between 10-5°C from Mediterranean coast to the north of Aegean coast. The mean July temperature is over 20°C. The mean yearly precipitation ranges between 400-2500 mm, most of which falls during the winter period. The amount of precipitation increases and temperature decreases towards the higher part of the mountain due to the altitude. The south-facing slopes, which are exposed humid airmasses, are cooler and retain more moisture on the Taurus Mountains. These climatic and topographic properties are responsible for the distribution of vegetation formations. Thus, Oro-Mediterranean forests composed of oaks, *Pinus nigra* Arnold. subsp. *pallasiana* begin over 800 m in the Aegean Region, and mountains forests associated with cedar, fir and black pine of Taurus Mountains commence over 800 m.

Shrub (Maqius and Garrigue) formation: Shrub vegetation, which is the secondary succession of the thermo-Mediterranean, occurs along the coastal belt of the region and it continues a few hundred km towards the inland part of the area through the depressions such as Gediz, Buyuk and Kucukmenderes grabens.

Maquis vegetation: In most cases it is originated from the deterioration of *Pinus brutia* Ten. forests as a result of human activities and other ecological conditions such as climate, soil type. Maquis vegetation is common in Western Turkey, up to 600–800 m. Maquis elements have a deep root system so that even they occur on the thin soil cover, stony-rocky areas. Most of them are evergreen and fast growing in character. *Olea europea* L., *Cerotonia siliqua* L., *Quercus coccifera* L., *Pistacia palestina* Boiss., *Pistacia lenticus* L., and *Arbutus andrachne* L. are the principal species of the maquis communities. In addition, some other sclerophyllus species including: *Philyrea latifolia* L., *Pistacia terebinthus* L., *Calicotome villosa* (Poir.)Link., *Rhamnus oleoides* L., *Myrtus communis* L., *Laurus nobilis* L., *Styrax officinalis* L., and *Spartium junceum* L. also occur in the maquis communities (Zohary 1973, Atalay 1994, 2002). If the maquis elements are cleared frequently, their biomass productivity increases. Maquis elements provide important source of forage for animals especially for black goat in Taurus Mountains. *Quercus coccifera* L., *Quercus ilex* L., *Pistacia lentiscus* L., *Cistus creticus* L., *Cistus salviifolius* L., and *Calicotome villosa* Link. are the species resistant to the forest fire, and they regenerate very fast with root shoots after fire (Neyisçi, 1993; Ozturk, 1995; Atalay and Efe, 2008).

Mostly, elements of maquis vegetation are common in the understory of *Pinus brutia* Ten. Maquis elements also become dominant vegetation type when *Pinus brutia* Ten. forests completely cleared by human. The maquis elements grow very well and attain 10 m and become tree form in the protected areas. Sparse maquis areas commonly occupied by *Pinus brutia* Ten. and again the maquis forms the understory layer in the *Pinus brutia* Ten. forest destroyed areas (Efe 2004, 2005). But densely maquis areas inhibit the germination of the red pine seeds.

Garrigue (or phrygana) vegetation: One of the most characteristic habitats of the Mediterranean region is garigue, a lowland vegetation community of poor soils, composed largely of thorny or aromatic short shrubs. This short shrub vegetation which is termed garrigue occupies all Aegean and Mediterranean coastal areas of Turkey. These low, thorny formations, composed mainly of hemispherical shrubs which are generally deciduous during the dry season, have developed where both maquis and red pine forests were completely cleared (Efe, 1997,1998a,1998b). There are no selective properties relating to parent materials. In fact one can find the garrigue in the same places where both *Pinus brutia* Ten. and maquis elements occur. But, garrigue vegetation is dominant in the areas where natural equilibrium destroyed and burnt.

In the Mediterranean region, garrigue vegetation is found where maquis and *Pinus brutia* Ten. forests have considerably been destroyed. Stony and arid parts of the thermo Mediterranean belt are covered with garrigue (Atalay *et al.,* 2008; Atalay and Efe, 2008). The best example can be seen in the Mut basin which is arid part of the region due to rainshadow of Taurus Mountains (Efe, 1998; Atalay, 2002).

Forest formation of Mediterranean region: Forest formation of the Mediterranean region can be divided into two main groups called Eu-(Lower) Mediterranean and Oro-Mediterranean according to climatic and altitudinal conditions.

***Pinus brutia* Ten. forests:** These forests form the climax forests of the lower belt of the Aegean and Mediterranean regions and are resistant to drought. Germination and regeneration are much more than the other forest trees and red pine seeds are very resistant to the forest fire (Neyisçi, 1993; Ozturk *et al*., 2002). After the fire the

area is occupied with *Pinus brutia* Ten. in short time if the burnt area is protected. Red pine begins at the sea level and extends up to 300-400 m in the Marmara, 700-800 m in the Aegean region and 1500 m above sea level in the Mediterranean region (Atalay, 1977; Atalay *et al.,* 1998).

Biomass productivity and the physiognomic features of the *Pinus brutia* are determined by the physical and chemical properties of parent materials, the amount of precipitation and ground water level. The biomass productivity is too low on the quartzite and peridotite-serpantine parent material. For example, red pine stands occurring on serpentine-peridotite parent material in the Datca Peninsula and in the vicinity of Köycegiz are in shrub form. In addition to this, poor stands like shrub exist on the quartzite and siliceous parent material around Foca district, north of Izmir. The best productive and widespread region of red pine forests are in Mediterranean region. They reach to the hight of over 1000 m on the south-facing slopes of Taurus Mountains and from mixed forest of the Oro-Mediterranean forest belt (Atalay *et al.,* 1998).

Forest formations of Oro-mediterranean region: In the moist parts of the oro-belt of Taurus Mountains, coniferous trees are dominant. Most of the forests are coniferous, comprised of *Pinus nigra* Arnold. subsp. *pallasiana*, *Cedrus libani* A. Rich, *Abies cilicica* Carr, and *Juniperus foettidissima* Willd. and *Juniperus excelsa* Bieb. which form the tree line (Davis 1965–1985, Davis 1988, Ozturk *et al*. 1991, Atalay 1987, 2002). *Cedrus libani* A. Rich. occurs in areas affected by the Mediterranean climate, while *Pinus nigra* Arnold. subsp. *pallasiana* mostly occurs inland, continental sites (Guidotti *et al*. 1986, Atalay 1987). *Pinus nigra* Arnold. subsp. *pallasiana* forests occur between 1200 and 2000 m in the Taurus Mountains. Blak pine grows very well on the soft parent materials such as flysch and colluvial deposits and often associated with the cedar and fir in the Taurus Mountains. Pure and well developed *Pinus nigra* Arnold. subsp. *pallasiana* stands occur around the Lake Beysehir, Lake Egirdir, and Sogut plateau extending between Antalya-Gazipasa and in the eastern part of Taurus Mountains (Kantarci 1982, Yucel and Ozturk 2000).

Abies cilicica Carr. forests occur between 1150-2000 m on the slopes facing north, and pure stands are only found on the north facing slopes. The optimum growth areas are generally found between 1200-1800 m. *Abies cilicica* Carr. occurs rarely in pure stands but mostly mixed with black pine and cedar forests are also found between 1300-1500 m in the Nur (Amanos) mountains, east of Iskenderun Gulf.

Cedrus libani A. Rich. being one of the climax trees of oro-Mediterranean belt begins at an elevation of 800 m and reaches up to 2000 m on the southern slopes of the Taurus Mountains, and also continues 2200 m in the interior section of the mountains. The main occurrence areas of cedar forests expand around Boz Mountain (Acipayam) in the west and Ahir and Nur (Amanos) mountains in the east. It continues towards the southern boundary of Inner Anatolia.

Cedar forests being in mixed and pure stands, occupy between 800-2000 m in the vertical direction in the southern parts of the Taurus and 1400-2100 m in the southern parts of the Taurus mountains, and 1800-2000 m in the Nur mountains, and cedar communities descend as low as 500-550 m in the eastern part of Nur mountains, west of Maras-Antakya graben. It can be clearly said that cedar avoids the extreme maritime as well as the continental region of Anatolia. For this reason optimum growing areas of cedar is found in the transitional region to be termed zonoecotone extending between Mediterranean and Inner Anatolia.

Cedar grows on all parent materials namely marly deposit, schist, quartzite, and limestones belonging to Tertiary, Mesozoic and Paleozoic era, Pure *Cedrus libani* A. Rich. stands occur only on the slopes facing north in the Taurus Mountains. But cedar grows only on the karstic lands in the Taurus Mountains. Juniper (*Juniperus excelsa* Bieb., *Juniperus foetidissima* Willd.) forests are common on the Taurus Mountains in areas where coniferous forests, composed of cedar and black pine, were entirely cleared. So that, it can be stated that juniper communities can be taken into consideration as the regressive and/or secondary succession. Indeed the seeds easily germinate after ingestion by birds in the destroyed coniferous forest areas. In the higher part of the forest belt *Juniperus communis* subsp. *nana* Willd. occurs.

Oak forests occur mainly between thermo and Oro-Mediterranean belt and extend as a belt at an altitude of 800-1200 m, and are common in the western and eastern parts of the Taurus Mountains. The common species of the oak forests are *Quercus libani* Olivier, *Q. frainetto* Ten., *Q. cerris* L., *Q. pubescens* Willd. *and Q. infectoria* Olivier. They become dominant in the areas where the effect of continental climatic conditions prevails. Because of their aspect and orientation, these areas receive high rainfall even in summer, an extremely rare event in the Mediterranean region. Thus, Black sea phytogeographical region elements such as; *Fagus orientalis* Lipsky forests with *Tilia argentea Desf.*, *Sorbus graeca* (Spach) Lodd. ex Nyman, *Acer* spp, *Rhododendron* ponticum L., and *Ilex colchica* Pojark. occur in these areas.

In addition to the Mediterranean vegetation, it is possible to find relicts of the Euro-Siberian phytogeographic realm on the south slopes of Dedegol and the western slopes of the Amanos Mountains (Atalay 1987). *Quercus vulcanica* Boiss. Et Heldr. which is the endemic and relic species for Taurus Mountains only grows within the karstic depression such as dolines in the Dedegol and Davraz mountains. In this habitat a group of humid trees and shrubs belonging to Euro-Siberian elements such as *Sorbus torminalis* (L.) Crantz, *Tilia rubra* DC., *Fraxinus excelsior* L., *Ulmus glabra* Huds., and *Ostrya carpinifolia* Scop. occur.

As to the Aegean geographical region, here oro-Mediterranean forests occur over the *Pinus brutia* Ten. forests on mountainous areas of the Aegean region such as Boz, Aydin, and Mentese Mountains. Humid forests which are found as small stands only occupy along the deep valley of the northern slopes of Boz

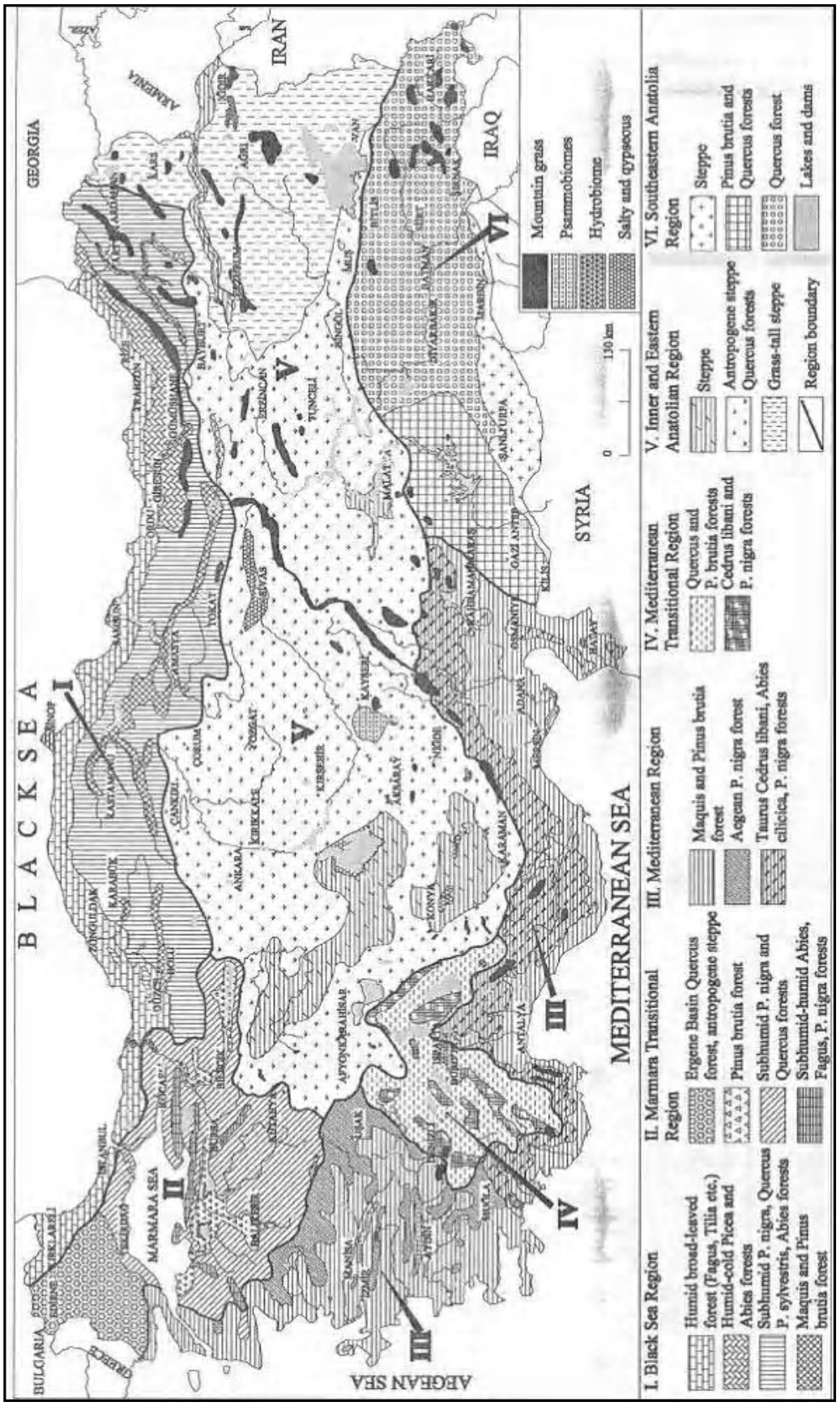

Fig. 1: Forests of Turkey according to climatic-ecologic regions

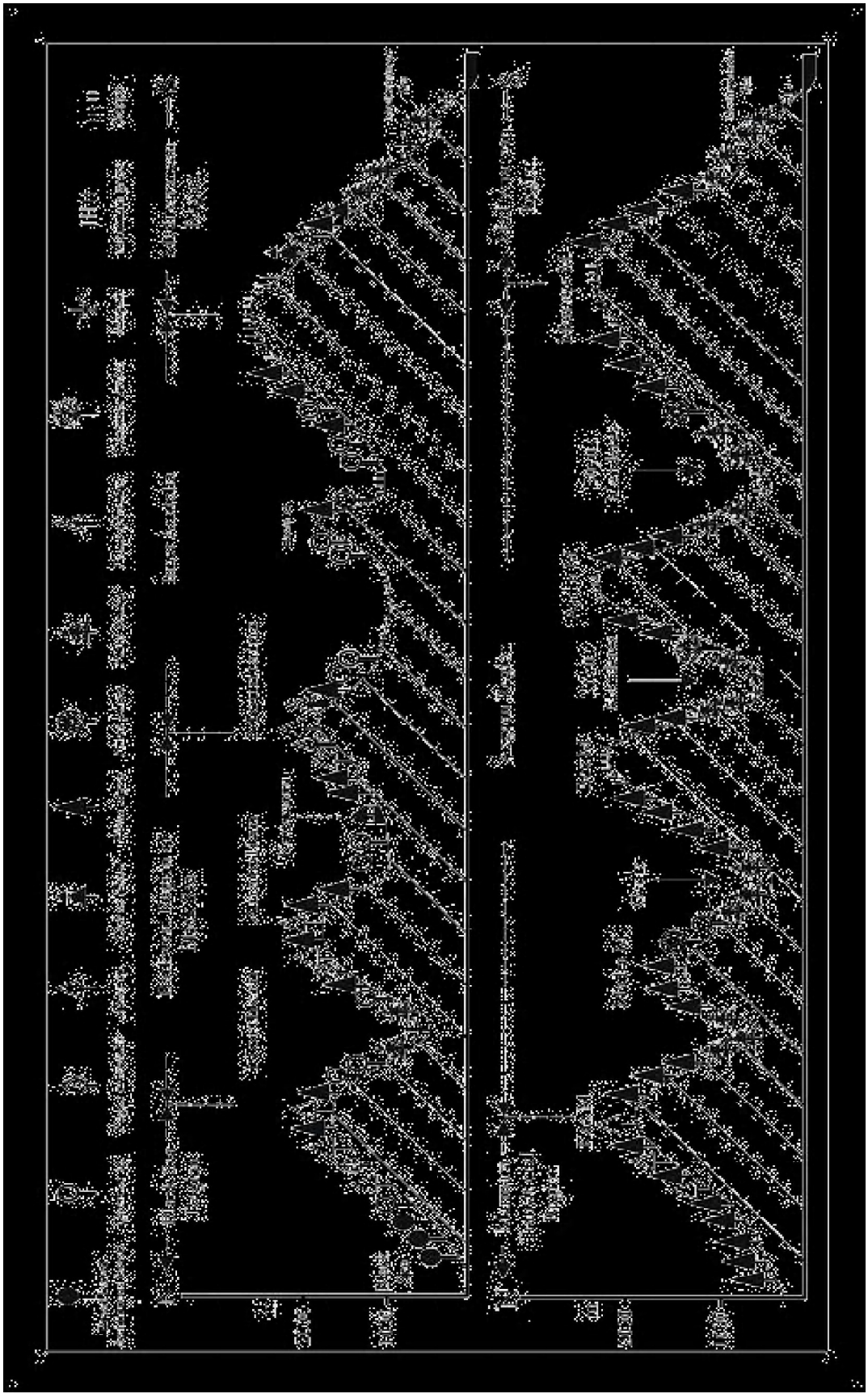

Fig. 2: North-South Vegetation cross-sections in Turkey

and Aydin Mountain mountains. Several *Castanea sativa* Mill. communities which are one of the prominent clusters occur on the northern slopes between 850-1000 m in Yamanlar Mountain, 800-1300 m in Boz Mountains in the western Turkey.

Humid forests composed of *Fagus orientalis* Lipsky*, Acer campestre* L., and *Tilia rubra* D.C. subsp *caucasica* (Rupr.) also accur as an enclave on the northern slopes of Murat Mountains in the eastern part of Aegean region. *Pinus pinea* L. forests occur on the sandy soil derived from the weathering of granite rocks in the Kozak plateau, on the north of Aegean region, on the gneiss in Koçarlý district in the interior part of Aegean region.

Dry forests are found on the south-facing slopes of the mountains. Their productivity is generally low and understory vegetation is poor. Dry forests composed of *Pinus nigra* Arnold. subsp*. pallasiana* and oak species such as *Quercus infectoria* Olivier*, Quercus ithaburensis* Decne. subsp. *macrolepis* (Kotschy) Hedge*, Quercus cerris* L., *Quercus frainetto* Ten.*, Quercus pubescens* Willd.occur on the southern slopes of mountains in the western Anatolia.

(IV) Forest of Mediterranean transitional region: This region, geographically called Lakes Region, is established between the Mediterranean climate and Inner Anatolian continental climate in the southwest of Anatolia. Here there are karstic-tectonic depressions and lakes, and closed basins that are separated by the mountain chains (Atalay and Efe, 2008). As a whole, this region climatically reflects semiarid continental effects. The mean annual precipitation decreases to 400 mm due to rain shadow. The mean annual temperature on the lowland is about 10-13°C, the mean winter temperature is above freezing point. The relative humidity during the summer season is very low (<40%).

***Pinus brutia* Ten. and *Quercus* spp. forests:** These forests are widespread on the lowland between 800-1000 m. The productivity of the *Pinus brutia* Ten. forest is lower than the Mediterranean region and the shrub layer of *Pinus brutia* forest mainly composed of *Quercus coccifera* L., and *Paliurus spina christi* Mill. Towards the north in the tectonic depression *Quercus* forest becomes dominant.

Cedrus libani A. Rich. and *Pinus nigra* Arnold. subsp*. pallasiana* forests that are called mountain forest occur Lakes district on western part of Taurus mountains. These forest starts soon after the *Quercus* species and they are replaced with *Cedrus libani* forests on the upper part of the mountains. Productive cedar forest is found on the north facing slopes of the mountains in the southern part of the region because the northern slopes of the mountains receives relatively humid and cool air coming from the northern sectors.

(V) Inner and eastern Anatolian region: This region encompasses all part of the Inner and Eastern Anatolian geographical regions. Semiarid continental climatic conditions are characterized by snowy and cold winters and hot and dry summers. The amount of yearly precipitation (less than 400 mm) is insufficient for the growth of trees so these areas are the natural occurrence areas of steppe vegetation in the lowland of Inner Anatolia and depression of Eastern Anatolia. The mean yearly precipitation of higher areas encircling the lowland region is more than 500-600 mm. Since the area is characterized by a dry continental climate, these forests are resistant to cold temperatures and water shortages and are therefore considered dry or xeric forests (Atalay, 1994). For example oak trees dominate the forests, including *Quercus pubescens* Willd. and *Quercus infectoria* Olivier, with steppe vegetation increasing to the east.

Dry forests: The high areas surroundings the Inner Anatolia are the main occurrence areas of *Pinus nigra* Arnold. subsp. *pallasiana*, *Quercus* spp. and *Juniperus* spp., and the remaining areas are occupied with the anthropogenic steppe. Oak stands are found as clusters in the transitional region between steppe and forest. *Pinus nigra* Arnold. subsp*. pallasiana* clusters occur on the mountains over 1200 m. *Pinus nigra* Arn. subsp. *pallasiana* forests are common on the Sundiken and Sivrihisar mountains in the northwest, Yazilikaya plateau, Sandikli and Murat mountains, the eastern section of Kutahya-Afyon line in the west.

***Pinus nigra* Arnold. subsp*. pallasiana* forests:** *Pinus nigra* Arn. subsp. *pallasiana* which is the climax vegetation of the subhumid-semiarid areas occurs on the marly brown forest soil between 1000-1500 m. Ayas mountain is one of the optimum growth areas of the black pine.

Pinus nigra Arnold. subsp*. pallasiana* and *Quercus pubescens* Willd. are the elements of climax forest in Inner Anatolia. The degraded areas of the black pine are occupied by *Quercus pubescens* Willd. and *Juniperus excelsa* Bieb.*, J. oxycedrus* L.*.. Quercus pubescens* Willd.*,* one of the sub-climax forest trees of Inner Anatolia was developed as a result of the destruction of *Pinus nigra* Arnold. subsp*. pallasiana*.

Dry forests consist of black pine*,* oak, juniper occur in the mountainous areas encircling the Inner Anatolia. Oak stands mainly composed of *Quercus pubescens* Willd., *Q. infectoria* Olivier are common, more or less, in the transitional areas extending between anthropogenic steppe and black pine forests. *Pinus nigra* Arnold. subsp*. pallasiana* forests occur at an altitude over 1200 m in the western part of the Inner Anatolia. A small *Pinus sylvestris* L. forest stand occurs on the high plateau surfaces in the vicinity of Akdagmadeni, Northeast of Inner Anatolia and also in a good stand on the Sündiken mountains, in the northwest of Inner Anatolia.

As a result of destruction, climax forests which are composed of black pine, oak and juniper forests have mostly destroyed in the higher areas and north-facing slopes of the mountains. Degraded and destroyed areas have been occupied by the steppe vegetation. The remnant stands of the oak and black pines which are found around Ankara named Beynam black pine forest and in the Yozgat National Park indicate the destruction activities.

***Quercus* spp. forests of Eastern Anatolia:** The moist areas of the middle and western mountains of the eastern Anatolia are one of the productive *Quercus* forest areas of Turkey. The prominent oak species are *Quercus infectoria* Olivier*, Quercus ithaburensis* Decne. subsp. *macrolepis* (Kotschy) Hedge*, Quercus brantii* Lindley*, Q. libani* A. Rich.*, Quercus robur* subsp. *pedunculiflora* (K. Koch) Menitsky and *Quercus petraea* Lieble. Mercan (Munzur) and Bingöl mountains are covered with the oak forests. But most part of the oak forests have been degraded and completely destroyed in many places in order to obtain fuel material and food for animals. Indeed, dried oak leaves are the main fodder for goats especially during the winter period. More than half of the oak forests in the vicinity of Bingol have been completely destroyed in last two decades. Thus, productive oak forest is found at limited locations.

(VI) Southeastern Anatolian region: This region which is the driest and hottest region of Turkey partly resembles the eastern and inner Anatolian regions in terms of plant communities. This region also represents the Mesopotamian floristic region. The mean annual temperature is about 17-18°C. The mean yearly rainfall is more than 500 mm, but the amount of yearly evapotranspiration is about 1800-2000 mm in the southern lowland of southeast Anatolia. Here the relative humidity decreases as low as one percent. The forest of the SE Anatolia can be divided into two groups.

***Pinus brutia* Ten. and *Quercus* spp. forests:** These forests both mixture and pure are found in the western part of southeast Anatolia due to the Mediterranean climatic influence. As a general rule the pinus stands on lowlands are generally composed of individual trees with poor trunk quality. The upper and subhumid areas are the main occurrence areas of oak species (*Quercus* Lindley*, Q. cerris* L. *and Q. infectori* Olivier).

Pure *Quercus* spp. forests: These forests are found in the eastern part of the Karaca volcanic mountain. The hilly and deeply dissected mountainous areas of the southeastern Taurus mountains are the natural occurrence areas of oak forests. *Quercus brandii* Lindley and *Quercus infectoria* subsp. boissieri are the dominant oak species in the area. But, productive oak forests are found in very limited localites due to the severe destruction.

Relict and endemic forests: Climatic changes occurred during the Pleistocene especially last glacial and early holocene is responsible for formation of relict forest stands. In the last glacial period, some parts of the mountainous areas were subjected to cold and semiarid climatic conditions and the area over 2000 m in the coastal mountains and 2500 m in the inner section of Anatolia were covered with glaciers. Some part of the mountainous areas extending as far as the southern high slopes of Taurus mountains and western Anatolia were covered with *Pinus sylvestris* L. and *Betula* sp. clusters. Presently a few relict *Pinus sylvestris* L. clusters occur in Uzunyayla (East of inner Anatolia), northern part of Ceyhan river watershed and the northern section of Malatya province (Van Zeist and Bottema, 1991). Betula clusters which are found on the mount Agri, eastern part of east Black sea mountains, Mercan mountains (Eastern Anatolia) and Nemrut caldera, NW of lake Van can be considered as relict vegetation (Atalay, 1992a,2008).

On the other hand, *Luquidambar orientalis* Mill. forests occurring the surrounding the lake Koycegiz, in the southwest Anatolia is the remnant of Tertiary hot-humid climatic conditions. The pure *Abies equi trojani* Aschers. et Sint. and mixed with *Pinus nigra* Arnold. subsp. *pallasiana* forests which are found on the northern slopes of the Kaz Mountains north of Edremit Gulf in western Turkey, can be taken into consideration as endemic forests.

The different geomorphologic units, climate features and geographical position of Turkey have allowed the development of rich vegetation. A large proportion of Turkey receives an average yearly rainfall of 640 mm which provides suitable conditions for natural forest cover. However, hundreds of years of human activity has resulted in the destruction of large areas of forest. The natural forests are most predominant on the Black sea, Aegean and Mediterranean coasts. They are principally made up of mixed coniferous and broadleaf species although large areas consist of pure confers such as *Pinus brutia* Ten., *Pinus nigra* Arnold. subsp. *pallasiana*, *Abies* spp., *Cedrus libani* A. Rich. and *Picea orientalis* (L.) Link. Of the broadleaf species, oriental beech and oak species are widely seen. In the lower reaches of the Black sea coast belt broadleaf species dominate, whereas higher up coniferous forests of *Picea* spp. and *Abies* spp. are found. In the lower parts of the Mediterranean region *Pinus brutia* Ten. is predominant species. At higher altitudes, there are *Pinus nigra* Arnold. subsp. *pallasiana*, *Cedrus libani* A. Rich. and occaisional *Abies cilicica* Carr. forests. Steppe terrain is widespread in central, east and south east Anatolia and oak forests are found sporadically in these regions.

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